Adjustment Method of Multistage Group Satisfaction in the Regulatory Plan

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Abstract

Aiming at the subjectivity and uncertainty for current regulatory plan adjustments, the intricate influencing factors are abstracted as graphs based on the mathematical graph theory. By making use of the optimal algorithm of multistage group satisfaction decision, each decision is weighted to find out a maximum weight route. By this way, a series of factors to be adjusted is got so as to conduct the rational and objective adjustment in the regulatory plan.

Keywords

Regulatory Plan; Adjustment; Multistage Group Satisfaction

Introduction

The regulatory plan has been developed for nearly 20 years in China (Ren Lu. 2007). It is a legal planning at the lower level in the urban comprehensive planning and at the upper level in the site plan, with the better operation and connecting link. The regulatory plan is made up of six aspects:

1. Control of land usage (land area, land boundary, land usage, and compatibility of land use);

2. Control of environmental capacity (plot ratio, building density, registered inhabitant density and greening rate);

3. Control of building construction (high limit, setback and interval of building);

4. Urban design guides (massing, form, color, space enclosure and articles of building);

5. Control of supporting facilities (municipal and public facilities);

6. Control of behaviors and activities (traffic activity and pollution control adjustment). (Xia Nankai, 2005)

With rapid development of China's urbanization and market economy, the regulatory plan has gradually become a part of market economy. This means that it should satisfy demands of urban industries continually. Of the serious legal significance as a legal rule (Li Jiangyun, 2003), the regulatory plan still needs to be adjusted and revised constantly with more uncertain and subjective factors intermingled. Only by this way, can the dynamic balance be reached to meet the benefit maximization in the industries. Up to now, the planning contents are adjusted basically in the regulatory plan adjustment, and they are mainly divided into two parts: adjustments of both land usage and the technical indicators. Based on the two parts, the adjustments of other factors are performed as well. However, the regulatory plan adjustment started later in China. In addition to more benefit factors, the adjustment is still aimless and subjective. Currently, our new field of the study is how to form a set of the scientific, objective and rigorous adjustment method to deal with factors between regulatory plans, so that the results of adjustment really reach benefit maximization and the city really develops sustainably.

There are numerous influencing factors of the regulatory plan adjustment, some of which present mutual unity or contradiction. Supposing the building height is reduced considering landscapes for some urban land, but the overall floorage can't be adjusted because of changes of height indexes. Meanwhile, it couldn't meet the requirement of urban development if plot ratio fails to increase. For such question, the conclusions are drawn through argumentation that plot ratio causes big pressure to urban road, infrastructure and public utilities, and even impacts the urban landscapes if the plot ratio would not be increased. Furthermore, it couldn't meet needs of the urban development (Yun Shuang, 2006). Facing such not big complex city, the planners can make non-uniform decisions, due to the fact that currently most of planners make the decisions only depending on their experience and existing information as well as intuition and preference. Just as US planner Ella S. pointed out that "the planners are always prisoners of knowledge in these years because all things in a city get entangled together." So, this paper intends to introduce weighting method and graph theory in mathematics into the adjustment of the regulatory plan,

so as to get the optimal matching solution objectively and reasonably.

Optimal Algorithm for Multi-Stage Group Satisfaction Decision

Basic Conception

1) *Definition of Graph*

$V(G)=\{v_1, v_2,\ldots, v_n\}$, where $V(G)\neq\emptyset$, called the set of nodes for Graph G.

E $(G)=\{e_1, e,\ldots, e_m\}$ is the G edge set, where e_i is $\{v_j, v_t\}$ or $<v_j, v_t>$. If e_i is $\{v_j, v_t\}$, e_i is called the undirected edge by v_j and v_t as endpoints; If e_i is$<v_j, v_t>$, then e_i is called the directed edge by $v_j$as the start point and by v_t as the final point.

ϕ G): $E\rightarrow\varsigma\times\varsigma$ is called the correlation function Yin Jianhong, 2003).

2) *Directed Graph*

The graph whose each edge is directed is called the directed graph (Yin Jianhong, 2003).

3) *Weight and Weighted Graphs*

Supposing Graph G= (V,E). Each edge (v_iv_j) f G corresponds to one number r $v_i, v_j)$ (briefly written as r_{ij}, called the weight of Edge(v_i, v_j). G and the weight on its edge are called the weighted graph Wang Chaorui, 2001).

Multistage Group Decision Model

$M=\{m_1, m_2, m_3,\ldots m_n\}$, and the interactional degree for influencing factors to be adjusted is written as T+1 limited adjusting states in the multistage group decision process; and the t-th decision state is t=(0,1,2…,T), i.e. the t-th decision state is the ideal one for the regulatory plan adjustment, but the state is realized by t-1 times of adjustment among influencing factors. Interactional sequence and their state of influencing factors are determined in the adjustment of the regulatory plan, that is, when x_t^i is determined, alternative solution x_{t+1}^j is also determined in the x_t^i succeeding state. In addition, each planner's evaluation value of influencing factors at levels is determined in the adjustment of the regulatory plan, where g_p stands for the evaluation value and effectiveness of Decision Solution x_{t+1}^j in x_t^i .

Graph G=(V, G) is established corresponding to the multistage group decision based on target and influencing factors as well as graph theory in the adjustment of the regulatory plan. $V(G)= X_0\cup X_1\cup\ldots\cup X_T$ is the point set of Graph G=(V, G), and also contains all influencing factors for the adjusting purpose in the regulatory plan adjustment, where$X_0=\{x_0\}$ is the initial state of the whole process, that is, the issue prior to adjustment and the reason why some land is adjusted in the regulatory plan. $X_T=\{x_T\}$ is the final stage in the entire process, i.e. an ideal state to be available by the adjustment. Let $e=\{x_t^i, x_{t+1}^j\}$, $e\in E$ (G); Solution x_{t+1}^j is the alternative decision solution of Solution x_t^i when and only when it is in succeeding state. From this, the edge set of Graph e (V, G) is formed. N planners evaluate each adjustment solution and its succeeding alternatives to form the weight vector on the middle edge of the graph. So, a directed graph with the weight vector (T+1) corresponding to multistage group decision issues is constituted.

The planner's decision weight λ_t^p can reflect each planner's authority and decision-making power at each stage, and it should meet $0\leq\lambda_t^p\leq1$ and $\Sigma\lambda_t^p=1(t=1,2,\ldots,T)$. As each planner has different cognitive competence and authority of research fields in the adjustment of the regulatory plan, λ_t^p is changeable at every stage (Zheng Wenting, 2008).

Steps of Algorithm for Multistage Group Satisfaction Decision

(1) n planners evaluate the graphs formed by the influencing factors which may be adjusted in the regulatory plan, and they conduct the evaluation based on one influencing factor, or respectively based on some influencing factors, written as $f_{tij}^p(x_t^i, x_{t+1}^j)$. The summing operation is done for $\lambda_t^p f_{tij}^p(x_t^i, x_{t+1}^j)$ to determine the edge weight of G=(V.E).

(2) Respectively sum weight values of influencing factors adjusted in the regulatory plan by the planners based on different factors, and re-sum the constituted weight values in the same dimension.

(3) The weight sum in one (x,x')route is called the distance from x to x',written as $d(x, x')$, that is, the sum weight formed after the weight summation is done for the connecting lines between each potential influencing factor and its succeeding influencing factors in the regulatory plan adjustment.

(4) Find out a route with maximum weight value, so that n adjustment factors are connected into a solution in the regulatory plan adjustment. Supposing Solution $R(x_t^j)$ is a group satisfaction policy in X_i state, the evaluation value for Solution x_t^j is the highest certainly,

i.e. the route d formed by the Solution x_t^j and the former solution is the biggest.

Based on (1), (2), (3) and (4), the group satisfaction policy issue can be transferred into the discovering of a route with the biggest weight in a directed weighted graph, and the route is also a satisfaction solution in the regulatory plan adjustment.

Then, $R=x_0x_1^j \dots x_{T-1}^j x_T$ corresponding solutions which are the cores needed to be improved and adjusted in the adjustment of the regulatory plan 7].

Case Study

Step 1: Supposing five planning experts as the decision makers make up a decision-making group to conduct the adjustment of land usage in regulatory plan under the state mandatory rules for some land, and purpose is to determine the land usage and how to get the optimal matching. In the objective and professional perspective, they perform weight comparison to the regulated influencing factors, so as to get the n biggest influencing factors as the support points of the directed graph, and jointly participate in and regulate three dynamic decision-making processes. $x_0$stands for the adjustment of the land usage to propose the issues to be solved; x_1^1 stands for the developing commercial land; x_1^2 stands for the developing industrial land; x_1^3 represents the developing residential land; x_2^1 is the feasible and compatible control of the land use by changing land usage; x_2^2 is the supporting facility to be met by different ways of adjustment; x_2^3 represents analysis on stream of people and logistics for the planned land or solving the traffic problem by changing the surrounding urban route of the land; and x_3 is sustainable development of the land. It is expressed as the directed graph with weight vector, i.e. weighted value.

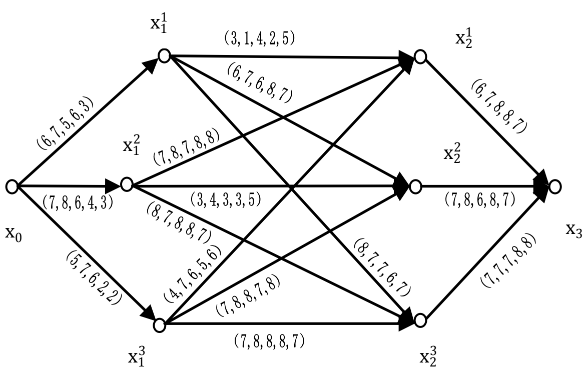

FIG. 1 DECISION MAKERS' A-BASED WEIGHT

Step 2: Determine the consideration factors of the weighted graph by the way of the planners' comprehensive evaluation and questionnaires. Because of numerous influencing factors and different influencing values, the four most important factors are summed up as follows: a. Good for the land development; b. Overall space pattern of a city; c. Forecast of population capacity and life quality; d. Economical benefit. The scoring is done on these influencing factors.

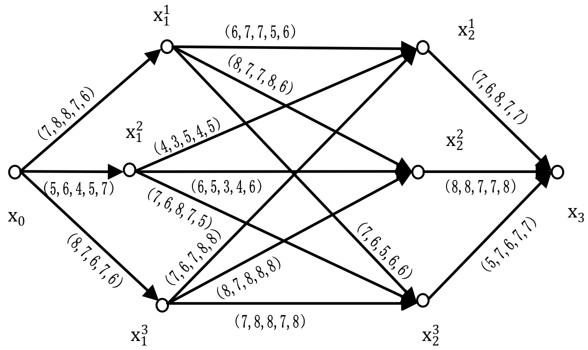

FIG. 2 DECISION MAKERS' B-BASED WEIGHT

Step 3: Analyze five decision makers' decision weight, that is, performing the dynamic evaluation based on five plan experts' authority, comprehensive experience in practice, and mastery of knowledge. The one expert's cognitive competence changes with the stage of the adjustment when the one conducts the regulatory plan adjustment in the different influencing factors. The evaluation at each stage is dynamic in order for more objective adjustment of the regulatory plan. Here, the total sum of the five planners' evaluation is stipulated as "1" which means a unit person, and their overall competence is not too much different each other, so as to reduce each planner's preference and deviation to the greatest extent with rationality. The scores at three stages are got respectively with comprehensive evaluation for planners, namely, λ_1^4 = (0.3, 0.3, 0.1, 0.2, 0.1), λ_2^4 = (0.4,0.1,0.1,0.3,0.1), λ_3^4 =(0.1,0.3,0.2,0.3,0.1) representing $x_0\ x_1^j$, $x_1^j\ x_2^j$ and $x_2^j\ x_3$ stages respectively. Five planners' evaluation values of the solution in the regulatory plan adjustment for a factor are shown in Figure 1. The evaluation values of the solution in the regulatory plan adjustment for b and c, d factor are shown in Figure 2 and Figure 3, Figure 4, respectively. Step 4: Calculate the scores at each stage for

influencing factors respectively based on the planning experts' evaluation at different stages, i.e. the weight on each edge as shown in Fig. 1, where, d(x_0, x_1^1)=0.3 ×6+0.3 ×7+0.1 ×5+0.2 ×6+0.1 ×3=5.9, d(x_1^1, x_1^2)=0.4× 3+0.1 × 1+0.1 × 4+0.3 × 2+0.1 × 5=2.8. By parity of reasoning, the weight on each edge is calculated in Fig. 1, 2, 3 and 4, and corresponding adjacent matrixes M_1 M_2, M_3 and M_4 are acquired. The matrix element is defined as follows:

$$A[i,j]=\begin{cases} P_{ij} & (V_i,V_j)\in E(G), i\neq j \\ 0 & i=j \\ \infty & if\ not \end{cases}$$

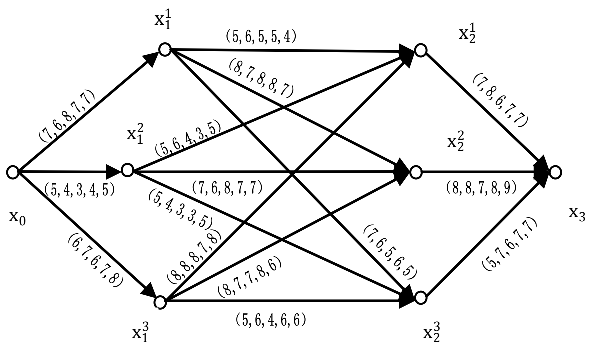

FIG. 3 DECISION MAKERS' C-BASED WEIGHT

Where, P_{ij} is the weight value on Edge (V_i,V_j), and ∞ stands for no connection between Vertexes i and j.

$$M_1=\begin{bmatrix} 0 & 5.9 & 6.2 & 4.8 & \infty & \infty & \infty & \infty \\ \infty & 0 & \infty & \infty & 2.8 & 6.8 & 7.1 & \infty \\ \infty & \infty & 0 & \infty & 7.5 & 3.3 & 7.8 & \infty \\ \infty & \infty & \infty & 0 & 5 & 7.3 & 7.5 & \infty \\ \infty & \infty & \infty & \infty & 0 & \infty & \infty & 7.4 \\ \infty & \infty & \infty & \infty & \infty & 0 & \infty & 7.4 \\ \infty & \infty & \infty & \infty & \infty & \infty & 0 & 7.4 \\ \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix}$$

$$M_2=\begin{bmatrix} 0 & 7.3 & 5.4 & 7.1 & \infty & \infty & \infty & \infty \\ \infty & 0 & \infty & \infty & 5.9 & 7.6 & 6.3 & \infty \\ \infty & \infty & 0 & \infty & 4.1 & 5 & 6.8 & \infty \\ \infty & \infty & \infty & 0 & 7.3 & 7.9 & 7.3 & \infty \\ \infty & \infty & \infty & \infty & 0 & \infty & \infty & 6.9 \\ \infty & \infty & \infty & \infty & \infty & 0 & \infty & 7.5 \\ \infty & \infty & \infty & \infty & \infty & \infty & 0 & 6.6 \\ \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix}$$

$$M_3=\begin{bmatrix} 0 & 6.8 & 4.3 & 6.7 & \infty & \infty & \infty & \infty \\ \infty & 0 & \infty & \infty & 5 & 7.8 & 6.2 & \infty \\ \infty & \infty & 0 & \infty & 4.4 & 7 & 4.1 & \infty \\ \infty & \infty & \infty & 0 & 7.7 & 7.6 & 5.4 & \infty \\ \infty & \infty & \infty & \infty & 0 & \infty & \infty & 6.9 \\ \infty & \infty & \infty & \infty & \infty & 0 & \infty & 7.9 \\ \infty & \infty & \infty & \infty & \infty & \infty & 0 & 6.6 \\ \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix}$$

$$M_4=\begin{bmatrix} 0 & 8.6 & 7.3 & 7 & \infty & \infty & \infty & \infty \\ \infty & 0 & \infty & \infty & 7.3 & 7.9 & 6 & \infty \\ \infty & \infty & 0 & \infty & 4.3 & 7.9 & 6.3 & \infty \\ \infty & \infty & \infty & 0 & 4.5 & 7.1 & 4.6 & \infty \\ \infty & \infty & \infty & \infty & 0 & \infty & \infty & 7.9 \\ \infty & \infty & \infty & \infty & \infty & 0 & \infty & 7.7 \\ \infty & \infty & \infty & \infty & \infty & \infty & 0 & 5.4 \\ \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix}$$

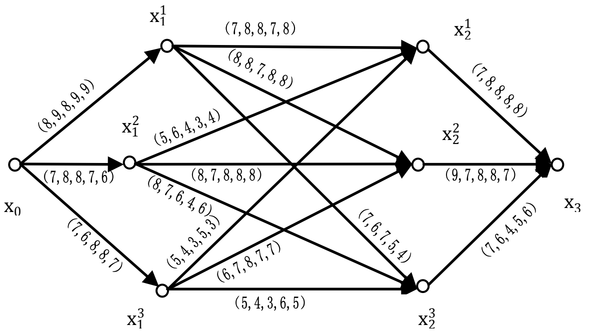

FIG. 4 DECISION MAKERS' D-BASED WEIGHT

Step 5: Sum M_1, M_2, M_3 and M_4, and get M, i.e. the weight value of solution for each influencing factor summed up by five planners based on different influencing factors in four aspects. The directed weighted graph corresponding to M is shown in Fig. 5.

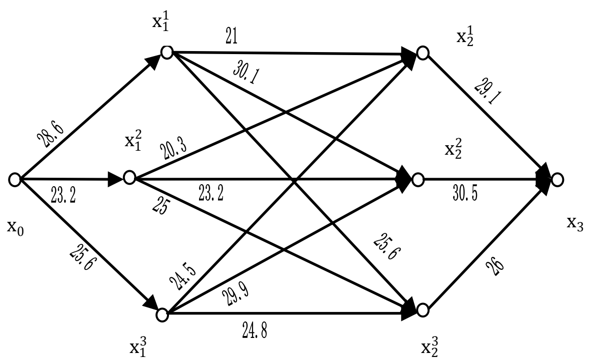

FIG. 5 SUM OF WEIGHTS AT STAGES

$$M = \begin{bmatrix} 0 & 28.6 & 23.2 & 25.6 & \infty & \infty & \infty & \infty \\ \infty & 0 & \infty & \infty & 21 & 30.1 & 25.6 & \infty \\ \infty & \infty & 0 & \infty & 20.3 & 23.2 & 25 & \infty \\ \infty & \infty & \infty & 0 & 24.5 & 29.9 & 24.8 & \infty \\ \infty & \infty & \infty & \infty & 0 & \infty & \infty & 29.1 \\ \infty & \infty & \infty & \infty & \infty & 0 & \infty & 30.5 \\ \infty & \infty & \infty & \infty & \infty & \infty & 0 & 26 \\ \infty & \infty & \infty & \infty & \infty & \infty & \infty & 0 \end{bmatrix}$$

Step 6: Find out a route with maximum weight value through calculation and comparison in Table 1 and 2. The so-called maximum weight value doesn't mean vertical comparison to each route, or maximum weight value of comparison at the same level, but an optimal route so that the matching of the decision solution between four influencing factors is the most stable. By the comprehensive comparison of matrixes in Table 1 and 2 we will get $\max\{d\ (x_0, x_1^j\ ,\ x_2^j\ ,\ x_3)\ \} = d(x_0 x_1^1\ x_2^2\ x_3)=88$, that is, this land should be mainly used for the commercial land, and the land usage should meet requirements of municipal and public service facilities, so that the land can be developed sustainably by a series of adjustment.

TABLE 1

	$x_0x_1^1$	$x_0x_1^2$	$x_0x_1^3$
x_2^1	56.3	43.4	50.2
x_2^2	58.6	46.3	55.2
x_2^3	54.2	48.1	50.9

TABLE 2

	$x_0x_1^1x$	$x_0x_1^1x$	$x_0x_1^1x$	$x_0x_1^2x$	$x_0x_1^2x$	$x_0x_1^2x$	$x_0x_1^3x$	$x_0x_1^3x$	$x_0x_1^3x$
x_3	87	88	77.2	74.1	75.7	71.1	80.9	84.6	73.9

Conclusions

(1) The intricate contradictory factors in the regulatory plan adjustment can be summed up by the multistage group satisfaction decision, and the planners' preference can be reduced to the greatest degree in adjustment to ensure that the solution is more reasoning. Some uncontrollable factors in adjustment are equally fit for the method.

(2) With the help of computer, the regulatory plan adjustment is applicable to solve more levels of or more detailing contradictory issues by the multistage group satisfaction decision. This is of positive significance to deal with the regulatory plan adjustment by artificial intelligence.

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